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Research Article

Real Time Locating Systems and sustainability of Perioperative Efficiency of Anesthesiologists

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Abstract

Objective: We determine if Real Time Locating Systems (RTLS) paired with automated notifications have a sustained effect on perioperative efficiency in anesthesiologists over a one-year period from the time of implementation.

Methods: A retrospective chart review of all outpatient and short-stay patients, who received general anesthesia at our ambulatory surgery center between July 1st, 2017 and December 31st, 2018 was performed. Patients included were over 18 years of age who presented for non-urgent cases with ASA classification of 1, 2, and 3. Additionally, only first cases of the day for individual anesthesiologists were included.

Time was used as a measure of efficiency between three comparison groups:

- Anesthesiologists who use RTLS prior to implementation of automated notification pairing for the period of 1 July 2017 to 31 December 2017.
- Anesthesiologists who use RTLS paired with automated notifications for the period of 1 January 2018 to 30 June 2018.
- Anesthesiologists who use RTLS paired with automated notifications for the period of 1 July 2018 to 31 December 2018.

The primary outcome measure duration (DUR) was collected from patient electronic records.

DUR was defined as duration of time, in minutes, from patient arrival to the Operating Room (OR) and initiation of induction by the anesthesiologist (exclusively for first cases of the day).

Results: During the initial six months, DUR between time of OR admission and time of induction was significantly reduced to 6.0 minutes (5.0, 8.0) post-implementation of automated notification pairing with RTLS. DUR then returned to pre-intervention baseline of 7.0 minutes (5.0, 9.0) during the subsequent six-month study period.

Conclusion: Initial results indicate that implementation of integrated RTLS technology enabled anesthesiologists at our institution to be more efficient during the perioperative period. However, this perceived benefit was not sustained over a 1-year period as our measure of efficiency DUR ultimately returned to the pre-intervention baseline.

Keywords: *Real Time Locating Systems (RTLS); Anesthesiologists; Operating Room (OR)*

Introduction

According to a 2016 survey of U.S. hospitals, 95% of respondents viewed health information technologies (HIT) as a strategically critical tool in improving efficiency of healthcare organizations [1]. Fifteen percent of administrators indicated that their hospitals already had RTLS in place and another 43% expressed interest and intent to purchase a system within the next two years [2].

The use of hospital real-time location systems (RTLS) can be divided into 4 broad categories: Tracking, Identification and Authentication, Automatic Data Collection and Sensing. These systems can be used for assets, patients, and staff [3]. The technology provides a unique view and understanding of how healthcare delivery settings behave and respond to operational design changes. Integration with other healthcare technologies might give these systems the ability to further increase efficiency, improve safety, and reduce operational costs [3].

Healthcare costs in the US have reached exorbitant levels, with the OR being the most expensive area in the hospital with each minute in time valued between $30 and $80. The pursuit and implementation of integrated systems and technologies has never been more pertinent. These technologies can not only lead to shorter OR times and costs, but also improved patient experiences [4,5].

Time points, specifically related to anesthesiologists, have been identified as an area in which the implementation of integrated systems can reduce OR time and costs. In many hospitals, the patient is brought into the OR by a member of the pre-operative team. The attending anesthesiologist will then be notified. The induction of anesthesia, and ultimately, the start of surgery, can only take place after the arrival of the anesthesiologist. Hence, delayed arrival of an anesthesiologist inevitably contributes to OR delays which translates to increased OR times and costs.

RTLS was first implemented at our free-standing ambulatory surgical in January 2016 with the goal of improving perioperative efficiency and OR workflow. Evolution of these systems led to integration of an alert notification system in January 2018 whereby an automated text message "*Patient on OR floor*" is sent to the attending anesthesiologist when the patient arrives in the OR [6-8].

In our initial studies we investigated whether the implementation of RTLS, followed by integration with automated response systems, improved OR efficiency by decreasing anesthesiologists' response times. While initial results showed statically significant improvements, we wanted to investigate whether these systems result in sustainable long-term solutions in the realm of OR efficiency [6-8].

Methods

A retrospective chart review was conducted for all outpatient and short-stay patients who received general anesthesia (GA) at our ambulatory surgery center between 1 January 2018 and 31 December 2018. To avoid the many possible delays associated with turnover time, only the first case of the day was included in this study. Patients were over the age of 18 with ASA classification of 1, 2, or 3 to eliminate the possibility that more complex patients may have a longer OR arrival to induction time. The primary measure of efficiency between the two comparison groups was the duration of time between anesthesia start time (defined as time when a patient arrives to the OR) and induction of anesthesia.

Time was used as a measure of efficiency between the following comparison groups:

Anesthesiologists who use RTLS prior to implementation of automated notification pairing for the period of 1 July 2017 to 31 December 2017.

Anesthesiologists who use RTLS paired with automated notifications for the period of 1 January 2018 to 30 June 2018.

Anesthesiologists who use RTLS paired with automated notifications for the period of 1 July 2018 to 31 December 2018.

The primary outcome measure duration (DUR) was collected from electronic medical records: DUR was defined as duration of time in minutes from patient arrival to the OR and initiation of induction (exclusively for first cases of the day).

The primary outcome was compared between the groups using the Wilcoxon rank sum test. Analyses were conducted with Stata 13.1 (StataCorp, College Station, TX). All statistical tests were two sided and $p < 0.05$ was considered significant.

Results

Through retrospective chart review of electronic patient records, 2394 cases matched the inclusion criteria of GA cases with patients over the age of 18 years that were first case of the day. All case types for all surgical subspecialties were included. Time frames used in our study were 1 July 2017 to 31 December 2017 (N = 758), 1 Jan 2018 to 30 June 2018 (N = 821) and 1 July 2018 to 31 December 2018 (N = 815). Of these, 1059 were outpatients versus 1335 short stay cases. ASA classification for all included cases were as follows: ASA 1 (N = 45), ASA 2 (N = 1421) and ASA 3 (N = 928) (Table 1).

	Pre-Intervention	**Month 1 - 6 post intervention**	**Month 7 - 12 post Intervention**
Number of patients	758 (32%)	821 (34%)	815 (34%)
Patient Type			
Outpatient	339 (45%)	355 (43%)	365 (45%)
Short stay patients	419 (55%)	466 (57%)	450 (55%)
ASA Class			
ASA 1	12 (1.6%)	19 (2.3%)	14 (1.7%)
ASA 2	452 (60%)	508 (62%)	461 (57%)
ASA 3	294 (39%)	294 (36%)	340 (42%)

Table 1: *Characteristics of study population.*

Our primary outcome measure, DUR, was significantly less at 6.0 minutes (5.0, 8.0) 1 - 6 months post-intervention compared to pre-intervention DUR of 7.0 minutes (5.0, 9.0) (P = 0.001). Post-intervention DUR (7 - 12 months post-intervention) was 7.0 minutes (5.0, 9.0) compared to 1 - 6 months post-intervention DUR of 6.0 minutes (5.0, 8.0) (p = 0.020). There was no significant difference between DUR pre-intervention and DUR post-intervention 7 - 12 months (p = 0.4) (Table 2-4 and Figure 1).

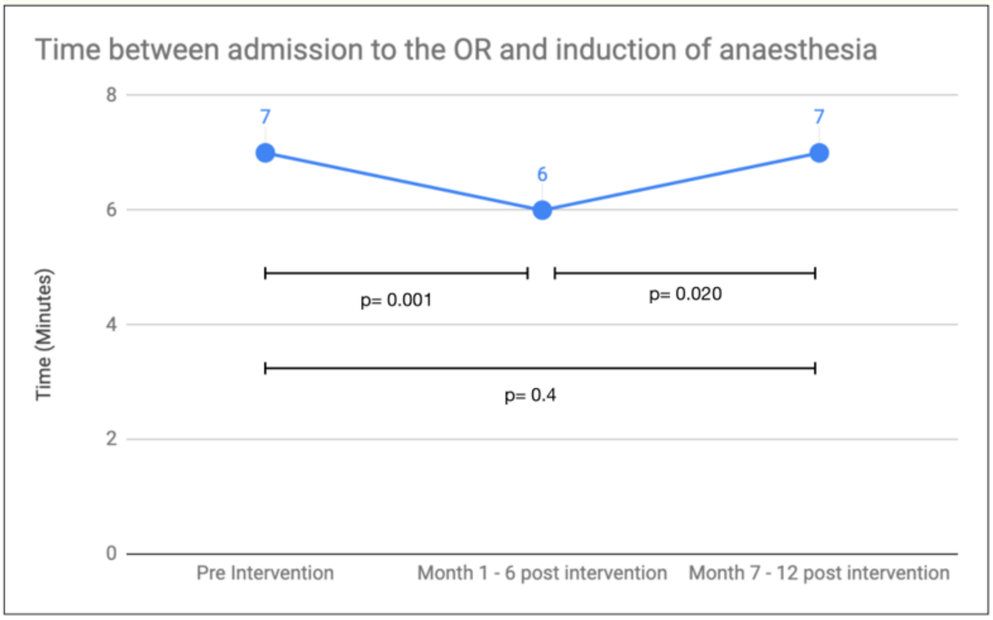

Figure 1: *Line graph comparing the DUR between the pre-intervention group, 1 - 6 months post-intervention and 7 - 12 months post-intervention group.*

DUR: Duration (in minutes) between when the patient is admitted to the OR and induction of anesthesia by the attending anesthesiologist.

	Pre-intervention (N = 758; 48%)	Month 1 - 6 post intervention (N = 821; 52%)	p
DUR	7.0 (5.0, 9.0)	6.0 (5.0, 8.0)	0.001

Table 2: *Duration (in minutes) between start and induction of anesthesia for pre-intervention and month 1 - 6 post-intervention groups. DUR: Duration (in minutes) between start of anesthesia and initiation of induction by the attending anesthesiologist. Values are presented as median (25th, 75th percentile).*

	Pre-intervention (N = 758; 48%)	Month 7 - 12 post intervention (N = 815; 52%)	p
DUR	7.0 (5.0, 9.0)	7.0 (5.0, 9.0)	0.4

Table 3: *Duration (in minutes) between start and induction of anesthesia for pre-intervention and month 7 - 12 post-intervention groups. DUR: Duration (in minutes) between start of anesthesia and initiation of induction by the attending anesthesiologist. Values are presented as median (25th, 75th percentile)*

	Month 1 - 6 post intervention (N = 821; 50%)	Month 7 - 12 post intervention (N = 815; 52%)	p
DUR	6.0 (5.0, 8.0)	7.0 (5.0, 9.0)	0.020

Table 4: *Duration (in minutes) between start and induction of anesthesia for month 1 - 6 and 7 - 12 post-intervention groups. DUR: Duration (in minutes) between start of anesthesia and initiation of induction by the attending anesthesiologist. Values are presented as median (25th, 75th percentile).*

Discussion

While still considered early in its development, RTLS technology has already proven to have a positive impact on healthcare initiatives. These range from improving patient safety and patient waiting times to increasing hand hygiene compliance and reducing various hospital costs [9]. Expanding these systems into the operating room could potentially have the same beneficial effect.

As shown in our previous study, facilities with access to RTLS had a significant improvement in OR efficiency and workflow compared to those without the technology. With further integration of information technology systems (e.g. automated push notifications), perioperative efficiency improved even more.

Our observed benefit of RTLS integrated with automated push notifications on duration of time taken from patient OR admission to the induction of anesthesia could be explained in the following ways:

The certified registered nurse anesthetist (CRNA)/resident can give his or her undivided attention to the patient during the pre-induction period and be freed from the need to notify the attending anesthetist.

The Hawthorne effect: The alteration of behavior by the subjects of a study due to their awareness of being observed. Healthcare workers may show changes in behavior that improve perioperative workflow if they know they are being tracked and monitored. More specifically the anesthesiologist would be more readily available to head to the OR once the automated notification has been sent.

The Hawthorne effect, also referred to as participant reactivity, has previously been documented in medical literature; behavioral modifications have a beneficial effect on study outcomes [9-12]. It is crucial to assess whether these behavioral changes are sustained or if there is a gradual weakening of the conditioned response that results in the behavior of the subject to decrease or disappear, known as extinction [13].

Our results show that the implementation of RTLS with automated response messaging improved the perioperative efficiency significantly during the first 6 months compared to the pre-intervention period. However, this observed benefit disappeared during the following 6 month-period, with the duration of time returning to pre-intervention baseline. This raises the question of whether improvements brought about by these technologies are truly sustainable solutions or merely result in short-lived behavioral changes.

Extinction, in our case, could be due to several factors. The lack of accountability or incentive, despite being tracked might lead to a lack of urgency over time. There is no reinforcing consequence to ensure that the anesthesiologist will rush to the OR when the alert notification is received. There is thus a need to examine the social and organizational factors that contribute to the success or failure of such systems in more detail [3].

It is also important to critically review the existence of the Hawthorne effect itself. In social research, there continues to be debate on whether to avoid the term. It has been proposed that researchers rather introduce specific psychological and social variables that affect the outcome in a study, rather than attributing it to the Hawthorne effect [14]. Further research needs to be done to better understand the existence and significance of the Hawthorne effect.

Other issues with RTLS that need to be addressed is the lack of consent for continuous location tracking, whether it is the patient, family members or healthcare workers. Additionally, the rights of an employer to location privacy has not been clearly established and the lack of policies might lead to medico-legal uncertainty [15,16].

Limitations of the Study

Limitations of our study include a relatively short study period and new or rotating staff's unfamiliarity with the technology and failure to use it appropriately. Furthermore, given the single center, specialized cancer-focus of our institution, it is not possible to generalize findings to all institutions implementing RTLS.

Conclusion

Implementation of Health Information Technologies (HIT) such as RTLS and event notification systems have shown to improve efficiency and care in various healthcare settings. The premise of its effect on the efficiency of anesthesiologist in the OR is largely based on behavioral change.

Initially, anesthesiologists who utilized integrated RTLS and automated notification systems were found to be more efficient in their perioperative workflow. After a period, there was a weakening of the conditioned response that resulted in the behavioral change of the anesthesiologist to diminish. It is important to consider psychological and social variables, given our findings that technology failed to have a sustained effect on perioperative efficiency. Further studies over a longer period may provide insight into the true sustainability of change brought about by implementation of healthcare technologies, as well as the existence and importance of the Hawthorne effect in a healthcare setting.

Acknowledgments

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